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Forty first-grade and 40 seventh-grade children were assigned at random to four groups of 20 each (two at each age level) and were administered four study-test trials involving oral presentation and oral recall of a list of four sentences of the form article-adjective-noun-verb-adverb. Half of the subjects at each level of age were given semantically well integrated (SWI) sentences to learn, while the other half were given semantically poorly integrated (SPI) sentences to learn. The sentences were constructed with the assistance of college associative sentence norms, on the assumption that such norms are a reflection of mature semantic competence. For all measures of recall, the SWI sentences were recalled better than the SPI sentences regardless of age of the subjects. In addition, there was evidence that the words in SWI sentences were recoded into larger chunks for storage than the words in SPI sentences and that age tended to increase chunking for both SWI and SPI sentences. As anticipated, the only evidence for phrase-chunking was found in the group of seventh graders that was exposed to SPI sentences. (Author/DO)

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SEMANTICS, PHRASE STRUCTURE AND AGE AS VARIABLES IN SENTENCE RECALL[1]

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40 first grade and 40 seventh grade Ss were assigned at random to 4 groups of 20 Ss each, 2 at each age level, and were administered 4 study-test trials involving oral presentation and oral recall of a list of 4 sentences of the form article-adjective-noun-verb-adverb. Half the Ss at each level of age were given semantically well integrated (SWI) sentences to learn, while the other half were given semantically poorly integrated (SPI) sentences to learn. The sentences were constructed with the assistance of college associative sentence norms, on the assumption that such norms are a reflection of mature semantic competence. For all measures of recall, the SWI sentences were recalled better than the SPI sentences regardless of age of the Ss. In addition, there was evidence that the words in SWI sentences were recoded into larger chunks for storage than the words in SPI sentences, and that age tended to increase chunking for both SWI and SPI sentences. As anticipated, the only evidence for phrase-chunking was found in the group of seventh grade Ss that was exposed to SPI sentences.

There is some evidence (Johnson, 1965) from paired-associate learning research that the words in a sentence undergo recoding into surface structure phrase units or chunks for storage. Some support for this finding comes from research by Rosenberg (in press, a) on sentence recall. However, the support was limited to sentences that were semantically poorly integrated (SPI), i.e., sentences containing weak semantic constraints (as indexed from norms of associative dependencies in sentences) between the subject nouns and the other items in the sentences. In the case of semantically well integrated (SWI) sentences (sentences containing strong semantic constraints), the evidence is that the individual words are recoded into units larger than the phrase, i.e., units that transcend the phrase boundary. The measure of recoding used in these studies was the probability of a word-to-word transitional error (TE),

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i.e., the probability of failing to recall a word correctly (a wrong word or nothing at all) given the previous word in the sentence was recalled correctly. A low TE probability would indicate a tendency to recall more than one word at a time.

Since the words in the SWI sentences in Rosenberg's (in press, a) study were stored in larger chunks than the words in SPI sentences, it was not surprising to find also that SWI sentences were recalled better than SPI sentences.

The sentences used in Rosenberg's research were constructed with the assistance of norms of associative dependencies in sentences of the form The old king ruled wisely and The doctor cured the patient (Rosenberg and Koen, 1968; Rosenberg, in press b). These norms were constructed by giving Ss (college undergraduates) sentence frames containing subject nouns (e.g., "The _____ king _____ _____.") to which they had to associate to produce the other items in the sentences. The norms consist in one case of frequency counts of the adjective, verb and adverb combinations that accompanied the subject nouns, and in the other case of frequency counts of the verb and object combinations that accompanied the subject nouns.

An examination of the high frequency word combinations generated by the subject nouns reveals that they represent by and large either part of the linguistic (dictionary) meaning of the subject nouns (e.g., The actor played the part.) or strong linguistic correlates of the experiences that we have had relevant to the referents of the subject nouns (e.g., The dog chased the cat). The term SWI, then, refers to sentences that contain such relationships between the subject noun and the remainder of the sentence.

The present study was concerned with the development of our ability to process SWI and SPI sentences differently. Specifically, it was hypothesized that if the associative sentence norms produced by adult Ss are a reflection of mature semantic competence, then the effect of Semantic Integration on sentence recall should increase with age. In addition, it was anticipated that older Ss would recode the words in SWI sentences into larger chunks than younger Ss. That is, the within- and between-phrase TE probabilities for the SWI sentences should decrease with age. With respect to SPI sentences, if there is a developmental factor involved in the ability

to recode the words in sentences into linguistic phrase units, this should be reflected in differences in the pattern of TE probabilities for older and younger Ss. Specifically, the probability of a TE at the phrase boundary should be higher than the probability of a TE within phrases for older Ss but not for younger Ss. However, such factors as increased memory capacity and increased familiarity of words should combine to reduce between- and within-phrase TE probabilities for SPI sentences as age increases. Of course, these factors should also contribute to the magnitude of the TE probabilities for SWI sentences for older Ss. In addition, the presence of the additional factor of semantic recoding should produce for older Ss lower between- and within-phrase TE probabilities for SWI sentences than for SPI sentences.

These hypotheses were tested in the present study by comparing the performance of first and seventh graders on a sentence recall task involving SWI and SPI sentences generated from college student norms.

Method

Subjects. Forty first grade and 40 seventh grade children were drawn randomly from one district of a school system. The seventh graders were drawn from the junior high school while the first graders were drawn from the six elementary schools that were "feeder schools" for the junior high. Bilingual, non-Caucasian and special class (e.g., retardation, speech therapy) pupils were eliminated from the list of potential Ss before the samples were selected. The Ss at each grade level were assigned at random to two groups of 20 each. The sexes were approximately evenly distributed in each of the four experimental groups, which were also comparable in Lorge-Thorndike non-verbal IQ.

Materials. Two lists of four SWI sentences and two lists of four SPI sentences were constructed using college norms (Rosenberg, in press b) for sentences of the form article-adjective-noun-verb-adverb. The use of two lists to represent each condition was for purposes of increasing the generality of the results. Each SWI sentence (e.g., The old king ruled wisely.) contained an adjective-verb-adverb combination selected from the top of the associative hierarchy for the subject noun. For each SWI sentence there was

an SPI counterpart (e.g., The poor king dined gravely.) that contained the same noun and an adjective-verb-adverb combination selected from the bottom of the associative hierarchy for the subject noun. The SWI and SPI sentences were made comparable with respect to Thorndike and Lorge (1944) word frequency and length (average number of letters). The adjectives, nouns and verbs were all AA or A words. The mean Thorndike and Lorge frequency for the adverbs was, for the SWI and SPI lists respectively, 26.75 and 21.69. An attempt was made to avoid intralist relationships in constructing the various lists. The sentences were typed on index cards to facilitate handling and reading during the experiment.

Procedure. The Ss were tested in isolated rooms that varied in terms of background stimuli and in terms of conditions of noise. There was no indication, however, that this was biased for any particular group. The order of testing the children from the different grades and conditions was random. The Ss were told that they would be read four sentences and that they were to remember as many of them as they could. It was emphasized that the order of the sentences was not important. For the recall task, they were instructed (prior to sentence presentation) to say the sentences back they could remember in any order they liked, and any parts of sentences as well. As soon as it appeared that the S had stopped responding, E said, "Can you remember anything else?" If the answer was "no," E went on to the next trial. The recall period lasted approximately 30 sec. for most of the Ss. The recall period was self-paced to insure, especially in the younger Ss, a level of recall that reflected what they had remembered.

There were four presentations of the lists, each of which was followed immediately by the recall task. The E read the sentences one after another using normal intonation and normal reading rate. Presentation time for each list was approximately 16 sec. The order of presentation of the sentences in each list varied randomly from S to S and from trial to trial. The E recorded each S's recall performance on paper and on magnetic tape.

Results

The protocols collected by the examiner were corrected against the magnetic tape recordings and then scored for verbatim recall. The scores for each S were summed over sentences and trials. Table 1 presents the means and SD's for total words recalled (TW), the proportion of the total words recalled that were in complete sentences (PWS), and the total sentences recalled (TS). Older Ss recalled more words, more complete sentences and a higher proportion of words in complete sentences than did younger Ss. The scores for the SWI condition were higher than the scores for the SPI condition on all measures for both age groups.

Insert Table 1 about here

A 2 x 2 factorial analysis of variance was performed on the TW and on the PWS data. The TW analysis resulted in an F (1,76) = 155.67, $p < .001$, for Age and an F (1,76) = 9.85, $p < .01$, for Semantic Integration. There was no significant interaction. The PWS data resulted in an F (1,76) = 67.69, $p < .001$, for Age and an F (1,76) = 7.33, $p < .01$ for Semantic Integration. Again there was no significant interaction.

Because the TS data did not meet the assumptions for a parametric statistic, a Kruskal-Wallis one-way analysis of variance was used here. The result for this analysis was significant beyond the .001 level. The effects of Semantic Integration were examined using the Mann-Whitney U test. The SWI sentences were recalled better than the SPI sentences by both younger ($p < .05$, two-tailed) and older ($p < .025$, one-tailed) Ss. Comparisons between age groups were also made and it was found that older Ss recalled more sentences than younger Ss in both the SWI and the SPI groups ($p < .001$, one-tailed). It would seem then that age produces a highly significant difference in the recall performance of Ss on all measures, and that strong semantic constraints in sentences facilitate recall for both groups on each measure.

Table 2 contains the means for content-word recall in relation to position within the presented sentence. Older Ss recalled more words at each position than younger Ss. The words in SWI sentences were recalled better than the words in SPI sentences at each position for both age groups.

However the difference in recall of words at the adjective and noun positions for the older Ss is not great. Noun-position words are recalled best by all groups.

Insert Table 2 about here

A three-way analysis of variance with repeated measures on one variable was used to examine the effects of Age, Semantic Integration, and Sentence Position on content-word recall. All three variables produced a significant F. For Age, $F(1,76) = 155.95$, $p < .001$; for Semantic Integration, $F(1,76) = 9.93$, $p < .01$; and for Position, $F(3,228) = 75.59$, $p < .001$. A significant Semantic Integration by Position interaction was also found; $F(3,228) = 4.51$, $p < .05$.

To identify the source of this interaction, separate 2 x 2 factorial analyses of variance were performed at each sentence position. Semantic Integration was not a significant variable in recall at either the adjective or the noun positions. However the effect of Semantic Integration was significant at the verb and adverb positions. For the verb position $F(1,76) = 13.52$, $p < .001$, and for the adverb position, $F(1,76) = 16.28$, $p < .001$. It would seem then, that the effect of Semantic Integration for this measure was limited to the content words in the verb phrase.

Transitional error (TE) probabilities were computed for each S for each word-to-word transition within the sentences by dividing the frequency with which a word following a correct word was wrong (either an omission or an incorrect substitution) by the frequency the preceding word was correct. This was done for the data summed over sentences and trials. Table 3 presents the means for the various word-to-word transitions for the four groups of Ss. The TE probabilities at each transition were higher for the younger Ss than for the older Ss for both levels of Semantic Integration. For the older Ss, the TE probabilities were higher for the SPI sentences than they were for the SWI sentences at all transitions except the adjective-noun (A-N) transition. For the younger Ss, the TE probabilities for the SPI sentences were slightly higher than they were for the SWI sentences at all transitions except the article-adjective (Ar-A) transition. The difference is appreciable at the Ar-A transition, but the direction is reversed.

Insert Table 3 about here

If there was a tendency to recode the words within the sentences into units larger than the word but smaller than the sentence, then the TE probabilities for each group should be unequal. A Friedman two-way analysis of variance was used with each group to test this hypothesis. The value of Xr^2 (3) for Group SWI7 was 13.19, $p < .001$; for Group SWI1, 17.82, $p < .001$; and for group SPI7, 13.82, $p < .001$. The Xr^2 for Group SPI1, however, did not even approach significance. Because of this last finding, no further TE comparisons were made within Group SPI1. If words are recoded into phrase units in the processing of a sentence, as Johnson (1965) suggests, the probability of a TE at the phrase boundary--the noun-verb (N-V) transition--should be higher than the probability of a TE within phrases. This hypothesis was examined by comparing the phrase boundary TE probability with the mean of the other transitions in the sentence using a Wilcoxon matched-pairs signed-ranks test. The means for the two measures respectively were, for Group SWI7 .24 and .18; for Group SWI1, .50 and .42; and for Group SPI7, .38 and .24. The TE probabilities are generally higher at the phrase boundaries than within phrase boundaries. However, a significant difference occurred only for Group SPI7 ($p < .005$, one-tailed). Thus, the evidence for phrase-structure recoding appears to be limited to SPI sentences.

The four groups were compared using a Kruskal-Wallis one-way analysis of variance at each content-word transition. For the A-N transition, $H = 22.4$; $p < .001$; for the N-V transition, $H = 11.45$, $p < .01$; and for the V-Av transition, $H = 8.2$, $p < .02$.

The A-N (within phrase), N-V (between phrase) and V-Av (within phrase) transitions were examined for the effects of Semantic Integration and Age using the Mann-Whitney U test. Semantic Integration did not affect the TE probability at the A-N transition for either age group. However, at the N-V transition TE probability was significantly lower in the SWI condition than in the SPI condition for the older Ss ($p < .025$, one-tailed) though not for the younger Ss. Similarly, for the V-Av transition TE probability was significantly lower in the SWI condition than in the SPI condition for the older Ss ($p < .05$ one-tailed) but not for the younger Ss.

The effect of Age on TE probability was significant for the SPI condition ($p < .05$, one-tailed) at the A-N transition, for both the SWI ($p < .001$, one-tailed) and the SPI ($p < .01$, one-tailed) conditions at the N-V transition, and for the SWI condition ($p < .025$, one-tailed) at the V-Av transition.

Discussion

Contrary to expectation, the effect of Semantic Integration on recall performance in the present study was not limited to the older Ss. Thus, it appears that the semantic competence reflected in adult associative sentence norms develops at an earlier age than had been originally thought.

There was also some evidence that the SWI sentences were processed differently than the SPI sentences by the first grade Ss. For one thing, proportionally more of the content words recalled were in complete sentences in Group SWI1 than in Group SPI1. For another, the TE probabilities were unequal for the SWI sentences but not for the SPI sentences. These observations suggest that the first graders may have been processing the SPI sentences much the same way as they would process a list of words. However, in terms of the between-group TE probability comparisons, it is clear that the effect of Semantic Integration was not as great as it was for the older Ss. In addition, as anticipated, there was no evidence for phrase-structure recoding in the data for the younger Ss. In this regard, the only evidence for phrase-structure recoding in the present study was in Group SPI7, a finding which is consistent with the hypothesis that the ability to utilize syntactic structure in processing sentences increases with age.

In spite of procedural differences between the present study and Rosenberg's (in press a) earlier one (he used visual presentation and written recall, and he controlled the exposure, recall and intertrial intervals), all the results for the seventh grade Ss support the conclusion derived from his study that the words in SWI sentences are recoded into larger chunks for storage than the words in SPI sentences. However, it is clear that the contribution of semantic constraints across the phrase boundary (the N-V transition) to recoding was greater than the

contribution of the within-phrase transitions, a finding which is consistent with Rosenberg's results for this type of sentence.

The N-V transition was also particularly sensitive to the effects of the variables associated with increased age. For this transition, increased age reduced the TE probabilities for both SWI and SPI sentences. However, for reasons which are not clear, TE probability decreased with age at the A-N transition for the SPI condition only, and at the V-Av transition for the SWI condition only. Nevertheless, overall, the hypothesis that the older Ss would recode the words in SWI and SPI sentences into larger chunks than the younger Ss appears to have been supported.

Thus, it is clear that the variables associated with age not only increase recall performance and chunking, but they influence the manner in which semantic and syntactic information in sentences is processed as well.

Footnotes

1. The research reported herein was performed in part pursuant to Contract OEC-3-6-061784-0508 with the U. S. Department of Health, Education and Welfare, Office of Education, under the provision of P. L. 83-531, Cooperative Research, and the provisions of Title VI, P. L. 85-864, as amended. This research report is one of several which have been submitted to the Office of Education as Studies in Language and Language Behavior, Progress Report No. VII, February 1, 1969.

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Table 1

Means and SD's for Various Measures of Recall

Groups	Measure TW	PWS	TS
SWI 1			
Mean	18.25	.26	1.35
SD	9.02	.26	1.64
SWI 7			
Mean	42.65	.59	6.60
SD	8.36	.19	2.75
SPI 1			
Mean	13.30	.12	.50
SD	6.37	.15	.68
SPI 7			
Mean	35.80	.49	4.65
SD	8.76	.49	2.83

Table 2

Mean Content-Word Recall as a Function of Position Within the Presented Sentence

	Sentence Position			
Group	Adj	Noun	Verb	Adverb
SWI 1	3.75	7.00	4.10	3.40
SWI 7	9.10	12.75	10.40	10.40
SPI 1	2.85	5.90	2.30	2.20
SPI 7	8.55	12.35	7.80	7.10

Table 3

Mean TE Probabilities

	Transition			
Group	Ar-A	A-N	N-V	V-Av
SWI 1	.61	.22	.50	.42
SWI 7	.29	.09	.24	.14
SPI 1	.54	.31	.64	.45
SPI 7	.32	.05	.32	.32